SCOPE OF ACCREDITATION TO ISO/IEC 17025-1999
& ANSI/NCSL Z540-1-1994

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CALIBRATION

Valid To: July 31, 2004 Certificate Number: 1899.01

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following calibrations:

I. Electrical – DC/Low Frequency

Parameter/Equipment	Range	Best Uncertainty[1, 2] (±)	Comments
DC Voltage System – Generate & Measure	(1 to 100) mV 100 mV (1, 10, 19, 100) V 1 kV	0.70 parts in 10^6 of F.S 0.6 parts in 10^6 0.3 parts in 10^6 0.7 parts in 10^6	Ratiometric measurement techniques performed utilizing Fluke 752A or 720A
DC Reference Calibration – Generate & Measure	10 V reference 1.018 V reference 1.00 V reference	0.3 parts in 10^6 0.5 parts in 10^6 0.5 parts in 10^6	7000 Automated DC calibration system
Resistance – Generate & Measure (Fixed Points)	1 Ω (10, 100) Ω (1, 10) kΩ 100 kΩ 1 MΩ 10 MΩ 100 MΩ 1 GΩ	2 parts in 10^6 1 parts in 10^6 1 parts in 10^6 2 parts in 10^6 4 parts in 10^6 10 parts in 10^6 44 parts in 10^6 65 parts in 10^6	Comparison by transfer methods to fixed points

Parameter/Equipment	Range	Best Uncertainty[1, 2] (±)	Comments
DC Current – Generate & Measure (Fixed Points)	100 μA 1 mA 10 mA 100 mA 1 A 10 A 20 A	4 parts in 10^6 4 parts in 10^6 5 parts in 10^6 16 parts in 10^6 18 parts in 10^6 9 parts in 10^6 59 parts in 10^6	Comparison to AC/DC shunts

Parameter/Range	Frequency	Best Uncertainty[1] (±)	Comments
Automatic AC/DC Transfer System – Generate & Measure			
AC Voltage (Fixed Points)			
100 mV	(10 to 20) Hz 30 Hz to 20 kHz (30 to 100) kHz 500 kHz 1 MHz	58 parts in 10^6 42 parts in 10^6 51 parts in 10^6 290 parts in 10^6 780 parts in 10^6	See Note 4
300 mV	(10 to 20) Hz 40 Hz to 100 kHz (200 to 700) kHz 1 MHz	27 parts in 10^6 16 parts in 10^6 170 parts in 10^6 780 parts in 10^6	See Note 5
1 V	10 Hz to 100 kHz 200 kHz 300 kHz 500 kHz 700 kHz 1 MHz	15 parts in 10^6 36 parts in 10^6 41 parts in 10^6 60 parts in 10^6 120 parts in 10^6 180 parts in 10^6	See Note 3
2 V	1 kHz 1 MHz	35 parts in 10^6 270 parts in 10^6	
3 V	(10 to 55) Hz 300 Hz to 100 kHz 200 kHz 500 kHz 700 kHz 1 MHz	27 parts in 10^6 17 parts in 10^6 38 parts in 10^6 110 parts in 10^6 150 parts in 10^6 240 parts in 10^6	

Parameter/Range	Frequency	Best Uncertainty[1] (±)	Comments
Automatic AC/DC Transfer System – Generate & Measure			
AC Voltage (cont) (Fixed Points)			
5 V	1 kHz 1 MHz	19 parts in 10^6 0.02 %	See Note 3
10 V	(10 to 20) Hz 40 Hz to 100 kHz 200 kHz 300 kHz 500 kHz 700 kHz 1 MHz	28 parts in 10^6 17 parts in 10^6 50 parts in 10^6 69 parts in 10^6 120 parts in 10^6 160 parts in 10^6 0.025 %	
20 V	1 kHz 500 kHz 700 kHz 1 MHz	14 parts in 10^6 120 parts in 10^6 220 parts in 10^6 0.026 %	
30 V	10 Hz 40 Hz to 100 kHz 200 kHz	28 parts in 10^6 18 parts in 10^6 50 parts in 10^6	
100 V	10 kHz 20 Hz to 200 kHz	26 parts in 10^6 22 parts in 10^6	See Note 5
300 V	40 Hz to 5 kHz (10 to 20) kHz 50 kHz 100 kHz	18 parts in 10^6 21 parts in 10^6 33 parts in 10^6 46 parts in 10^6	
500 V	100 kHz	82 parts in 10^6	
700 V	50 kHz 100 kHz	51 parts in 10^6 82 parts in 10^6	See Note 6
1000 V	(40 to 300) Hz (1 to 10) kHz (20 to 30) kHz	25 parts in 10^6 20 parts in 10^6 43 parts in 10^6	

Parameter/Range	Frequency	Best Uncertainty[1] (±)	Comments
Wideband AC Voltage – Into 50 Ω			See Note 7
1 V & 3 V	(1 to 10) MHz 20 MHz 30 MHz	0.19 % 0.32 % 0.38 %	
AC Current – Generate & Measure			Comparison to AC/DC shunts
100 μA	(10 to 100) Hz 100 Hz to 3 kHz 5 kHz	60 parts in 10^6 45 parts in 10^6 100 parts in 10^6	
1 mA	(10 to 100) Hz 300 Hz to 3 kHz 5 kHz	60 parts in 10^6 45 parts in 10^6 45 parts in 10^6	
10 mA	(10 to 100) Hz 300 Hz to 3 kHz 5 kHz	60 parts in 10^6 45 parts in 10^6 45 parts in 10^6	
100 mA	(10 to 100) Hz 300 Hz to 5 kHz	62 parts in 10^6 48 parts in 10^6	
1 A	(10 to 100) Hz 300 Hz to 1 kHz (3 to 5) kHz	64 parts in 10^6 51 parts in 10^6 160 parts in 10^6	
10 A	10 Hz 20 Hz 40 Hz to 10 kHz 20 kHz	60 parts in 10^6 88 parts in 10^6 50 parts in 10^6 100 parts in 10^6	
20 A	10 Hz to 1 kHz 5 kHz 10 kHz 20 kHz	0.022 % 0.031 % 0.061 % 0.10 %	See Note 8
Rise Time –			Measurement of 9500 oscilloscope calibrator, risetime output at 70 ps, 150 ps and 500 ps up to 3 V pk-pk into 50 Ω
(70, 150, 500) ps	1 MHz	7 ps	

Parameter/Range	Frequency	Best Uncertainty[1] (±)	Comments
Phase – 0° to 360°	10 Hz to 10 kHz (11 to 30) kHz	0.05° 0.5°	Clarke-Hess 6000
Capacitance – Measure (Fixed Points)			
1 pF	1 kHz	25 parts in 10^6	Andeen Hagerling 2500A within 10 % of the specified value
10 pF		18 parts in 10^6	
100 pF		9 parts in 10^6	
1000 pF		9 parts in 10^6	
10 000 pF		10 parts in 10^6	
100 000 pF		18 parts in 10^6	
1 000 000 pF		69 parts in 10^6	
(350, 480) pF	1 kHz	4000 parts in 10^6	Fluke PM6304C in an automated 55XX calibration system
(0.6, 1) nF		1700 parts in 10^6	
(1.2, 3) nF		1100 parts in 10^6	
3.3 nF		1300 parts in 10^6	
(10.9, 12, 30) nF		600 parts in 10^6	
33 nF		800 parts in 10^6	
(109, 120, 300) nF		600 parts in 10^6	
0.33 μF	100 Hz	800 parts in 10^6	
(1.09, 1.2, 3) μF		600 parts in 10^6	
3.3 μF		800 parts in 10^6	
(10.9, 12, 30) μF		600 parts in 10^6	
33 μF		800 parts in 10^6	
(109, 120, 300) μF		1100 parts in 10^6	
(330, 1100) μF	50 Hz	1300 parts in 10^6	

Parameter/Equipment	Range	Best Uncertainty[1] (±)	Comments
Electrical Calibration of Thermocouple Reference Junction	21 °C to 26 °C	0.05 °C	Automated 55XX calibration system

III. Electrical – RF/Microwave

Parameter/Range	Frequency	Best Uncertainty[1] (±)	Comments
RF Flatness – Measure			Utilizing IFR 6960B and R & S NRVS power meters to verify flatness from reference frequency setpoints.
(+18 to +12) dBm	1 MHz to 1 GHz	1.5 %	
(+9 to +3) dBm		1.5 %	
-6 dBm		1.5 %	
-16 dBm		1.5 %	
-26 dBm		2.5 %	
-30 dBm		2.5 %	
(+17 to +15) dBm	1 GHz to 3.2 GHz	1.7 %	
(+15 to +4) dBm		1.2 %	
(+1 to -27) dBm		0.98 %	

IV. Time and Frequency

Parameter	Range	Best Uncertainty[1] (±)	Comments
Frequency – Generate & Measure	< 10 Hz	0.06 parts in 10^6	GPS locked frequency standard
	10 Hz to 225 MHz	0.03 parts in 10^6	
	(1 to 225) MHz	0.02 parts in 10^6	
	225 MHz to 3.2 GHz	0.02 parts in 10^6	

V. Thermodynamic

Parameter	Range	Best Uncertainty[1] (±)	Comments
Temperature – Generate & Measure	-25 °C to 50 °C	0.013 °C	Hart 5699 SPRT
	50 °C to 100 °C	0.015 °C	
	100 °C to 200 °C	0.017 °C	
	200 °C to 600 °C	0.025 °C	

Note 1. Best Uncertainties represent expanded uncertainties expressed using a coverage factor of $k = 2$ which provides a level of confidence of approximately 95 %. The uncertainties shown relate to voltages and frequencies that lie within ± 10 % of the specified values.

Note 2. The uncertainty quoted on an A2LA certificate will include that of the reference standard plus any uncertainties attributable to the device under test during calibration.

Note 3. For intermediate frequencies between spot points up to 100 kHz, the uncertainty will be the greater of the two. For frequencies greater than 100 kHz, an allowance of 50 % of the greater of the uncertainties of the adjacent known points must be added. The uncertainties are applicable to the calibration of AC voltage sources with 4-terminal output sensing capability and for AC voltage measuring instruments simultaneously connected to the AC voltage source.

Note 4. For intermediate frequencies between spot points up to 100 kHz, where an interpolation of the TVC's reported AC/DC difference is required, an additional allowance of 50 % of the greater of the uncertainties of the adjacent points must be added. The uncertainties are applicable to the calibration of the Datron model 4920 AVMS.

Note 5. For intermediate frequencies between spot points, the uncertainty will be the greater of the two. The uncertainties are applicable to the calibration of AC voltage sources with 4-terminal output sensing capability and for AC voltage measuring instruments simultaneously connected to the AC voltage source.

Note 6. For intermediate frequencies between spot points up to 30 kHz, where an interpolation of the TVC's reported AC/DC difference is required, an additional allowance of 50 % of the greater of the uncertainties of the adjacent points must be added. The uncertainties are applicable to the calibration of AC voltage sources with 4-terminal output sensing capability and for AC voltage measuring instruments simultaneously connected to the AC voltage source.

Note 7. For intermediate frequencies greater than 10 MHz, where an interpolation of the TVC's reported AC/DC difference is required, an allowance of 50 % of the greater of the uncertainties of the adjacent known points must be added. The uncertainties are applicable to the calibration of AC voltage measuring instruments with 50 Ω input terminations.

Note 8. Using the 4953 shunt above 11 amperes: The shunt in the 4953 is specified with a thermal resistance of 3°C per watt and a temperature coefficient of 3 parts in 10^6 per °C. This means for every watt of power dissipated it heats by 3 degrees (corresponding to a 3° rise at 10 A), and for every degree of temperature change its value changes by 3 parts in 10^6. So, at 20 amperes it will heat by 12 degrees and change by 36 parts in 10^6 (additional uncertainty). The 4953 is actually rated for 11 amperes continuous usage. A good rule of practice is 1 to 10. If the 4953 is used of 1 minute above 11 amperes, then allow it to cool for 10 minutes before using it again.